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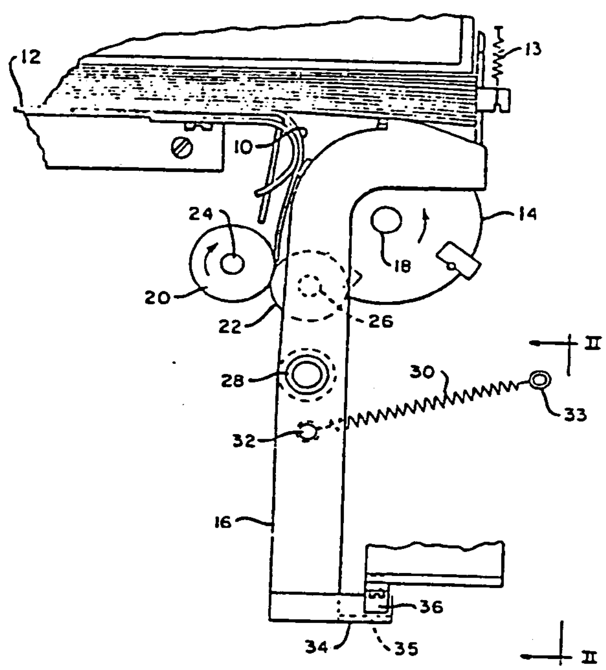
(54) Title: APPARATUS FOR DETECTING THE PASSAGE OF MULTIPLE DOCUMENTS

(57) Abstract

An apparatus for detecting the passage of multiple documents (10) in a transport system, including a pair of rollers (20, 22) between which said documents (10) are arranged to pass and which are displaceable by an extend dependent on the thickness of one document or multiple documents simultaneously passing therebetween. This displacement is measured by the movement of a graded density translucent member (34) between the photodiode (46) and sensor (40) of a detector (36). Electronic circuitry associated with the detector (36) indicates the presence of a record member (10) between the rollers (20, 22), and also the presence of multiple record members (10). The graded density of the member (34) allows the circuitry to detect only the displacement from the static position of the rollers (20, 22) eliminating the necessity for adjustment due to wear, temperature, and other mechanical factors.



documents passing therethrough, characterized by detecting means which is coupled to said gauging means and which is arranged to produce an output which progressively varies in response to a displacement of said gauging means, and circuit means, responsive to said detecting means, for producing an indication of whether multiple documents have simultaneously passed through said gauging means.

Brief Description of the Drawings

One embodiment of the invention will now be described, by way of example, with reference to the accompanying drawings, in which:

Fig. 1 is a diagrammatic view illustrating certain components of a currency dispenser;

Fig. 2 shows a partial sectional view of the currency dispenser taken along the line 2-2 of Fig. 1;

Fig. 3 is a schematic diagram of the monitoring circuitry of the currency dispenser;

Fig. 4 shows the unfiltered waveform of a single bill passing through the currency dispenser with its leading edge folded over;

Fig. 5 shows the unfiltered waveform of a double bill passing through the currency dispenser;

Fig. 6 shows the waveforms of several bills as inputs to the doubles detection comparator;

Fig. 7 shows the waveforms of several bills as inputs to the presence detection comparator;

Fig. 8 is a graph of the output voltages of several detectors versus displacement of the film strip;

Fig. 9 is a graph of the normalized output voltage of several detectors versus displacement of the film strip from the energized center position.

Best Mode of Carrying Out the Invention

Referring now to Fig. 1, there are shown certain components of a currency dispenser. Currency bills

A processed photographic film strip 34 is bonded along a protrusion 35 on the end of arm assembly 16. Film strip 34 is attached to arm assembly 16 such that it moves between the light source and sensor of a detector module 36 as the bottom end of arm assembly 16 is displaced. Since film strip 34 is processed in such a manner as to exhibit a relatively rapid change in optical density in a direction parallel to its length, the described motion of arm assembly 16 will change the amount of light activating the sensor of module 36. Thus, the electrical output of detector 36 is relative to the position of arm assembly 16.

In the present embodiment, the currency dispenser monitor is used to detect the presence of a single bill in addition to sensing the presence of multiple bills. However, due to several different factors, the home position of rollers 20 and 22 may change. Causes for the position drift may be variations in the resilience of the polyurethane surface covering of the rollers, wearing of the surfaces, ink deposits from the bills, wear in the bearings, or changes in ambient temperatures which cause expansion or contraction of the machine base and components. Experimental analysis of this home position drift indicates that it may shift plus or minus 0.075 centimeters from its initial position. Therefore, assuming a 0.075 centimeter displacement being necessary for detecting multiple bills, a linear measurement range of 0.225 centimeters is preferred for satisfactory operation of the doubles detector.

In the preferred embodiment, for cost considerations it is desirable to use a low-cost and commercially-available component in the circuit of detector 36 which is pre-aligned, and has a sufficiently high electrical output to provide direct drive of the associated electronic circuitry. A satisfactory component is General Electric type H13B1 photon-coupled interruptor

line 45 is also applied to a filtering combination of resistor 49 and capacitor 50. The coupling capacitor 50 blocks the DC component of the voltage at 45, which voltage is proportional to the quiescent position of film strip 34, arm assembly 16, and roller 22, allowing the circuit to respond only to changes in the position of film strip 34 between the components of detector 36. Thus, the circuit of Fig. 3 is independent of the static position of rollers 20 and 22, and reacts only to a physical movement of roller 22, which also causes movement of arm assembly 16 and film strip 34; mechanical drift of the static roller position will not affect the proper operation of the circuit.

Current to operate photodiode 46 is supplied from a voltage regulator 51 via a potentiometer 52. Regulator 51 may be an integrated circuit chip, such as Motorola Type MC1723CL or its equivalent, and serves to insure a sufficient calibrated current supply to photodiode 46 for proper operation. Regulator 51 and its associated components (resistors 54, 56, 58 and capacitor 60) may be eliminated if the power supply used to drive the circuit is sufficiently stable.

The output 61 of regulator 51, which is approximately 8 volts, is applied to another portion of the detection circuitry via resistors 62 and 64 and a diode 66. Diode 66 tends to hold the voltage across resistor 64 on the cathode of capacitor 50, which provides a fast recovery from the charge condition on capacitor 50.

The voltage at 68 is applied to the non-inverting input 69 of a differential comparator 70 via an integrating network of resistor 72 and capacitor 74. Comparator 70, which may be a Motorola type MC1414L or its equivalent, detects the presence of more than one bill between rollers 20 and 22. The reference voltage for the inverting input 75 of comparator 70 is generated when the supply voltage at 42 is transmitted across a

amplitude to trigger comparator 70, which would output a false double detection signal. As a comparison, Fig. 5 shows the waveform of the voltage at 68 when a double bill travels between rollers 20 and 22. The signal in Fig. 5 shows the initial bounce caused by the double bill entering rollers 20 and 22, but the signal also remains at a sufficient level for triggering comparator 70 for a longer time period, due to the extra thickness along the entire length of the bill. When the integrating network is used, the initial bounce is softened, allowing comparator 70 to detect only true double bills.

Fig. 6 shows waveforms of the signals generated by various bills at input 69 to comparator 70, which signals have been smoothed by the integrating network of resistor 72/ capacitor 74. Line 110 represents the double detection threshold; any signal rising above this will trigger comparator 70.

Signal 112 represents a double bill with its leading edge folded back approximately one-half inch; it is readily detected by comparator 70. Signal 114 shows a double bill; it is also detected by comparator 70. Signal 116 represents a single bill with its leading edge folded back approximately one-half inch; the integrating network has filtered the signal so that it will not cause comparator 70 to falsely trigger. Signal 118 shows the waveform for an unfolded single bill; it also is not great enough to activate comparator 70. Finally, the idle noise of the circuitry is represented by signal 120.

A lesser degree of integration is provided by the integrating network of resistor 94/capacitor 96, which balances the signal to eliminate noise pulses from mechanical shock, and yet preserve the pulse width as a means of detecting the time of bill entry and removal from rollers 20 and 22. Fig. 7 shows waveforms of the signals generated by various bills at input 90 to comparator 92, which signals have been smoothed by the

using a 4 volt output across phototransistor 40. The normalized operating curves 140a and 142a of the detectors used in Fig. 8 are shown in Fig 9. The graph of Fig. 9 plots the normalized detector output against the "centered" or normalized position of the film strip. Curves 140a and 142a show that, over a 0.254 centimeter range (± 0.127 centimeters from the normalized position), the output voltages of two commercial detectors can be normalized to obtain a uniform response.

Typical values of the components of the circuit of Fig. 3 may be as follows:

Resistors	Value
82,88,100,106	.1K ohms
72,47,94,58	6.8K ohms
78	390 ohms
49	33K ohms
64	750 ohms
62	7.5K ohms
54	680 ohms
56	820 ohms

Capacitors	Value
43	.01 microfarads
44,74	4.7 microfarads
50	15 microfarads
96	1 microfarad
50	100 picofarads

Potentiometers	Value
52, 84, 102	500 ohms

Diodes	Value
80	1N748A
66	1N906

4. (concluded)
varying translucency and is arranged for movement between a light source (46) and a light sensing means (40) included in said detecting means, in dependence on displacement of said gauging means (16, 20, 22), the arrangement being such that said light sensing means (40) produces an output (45) the magnitude of which varies in response to movement of said control means (34).

5. An apparatus according to claim 4, characterized in that said control means (34) is a translucent member of graded optical density.

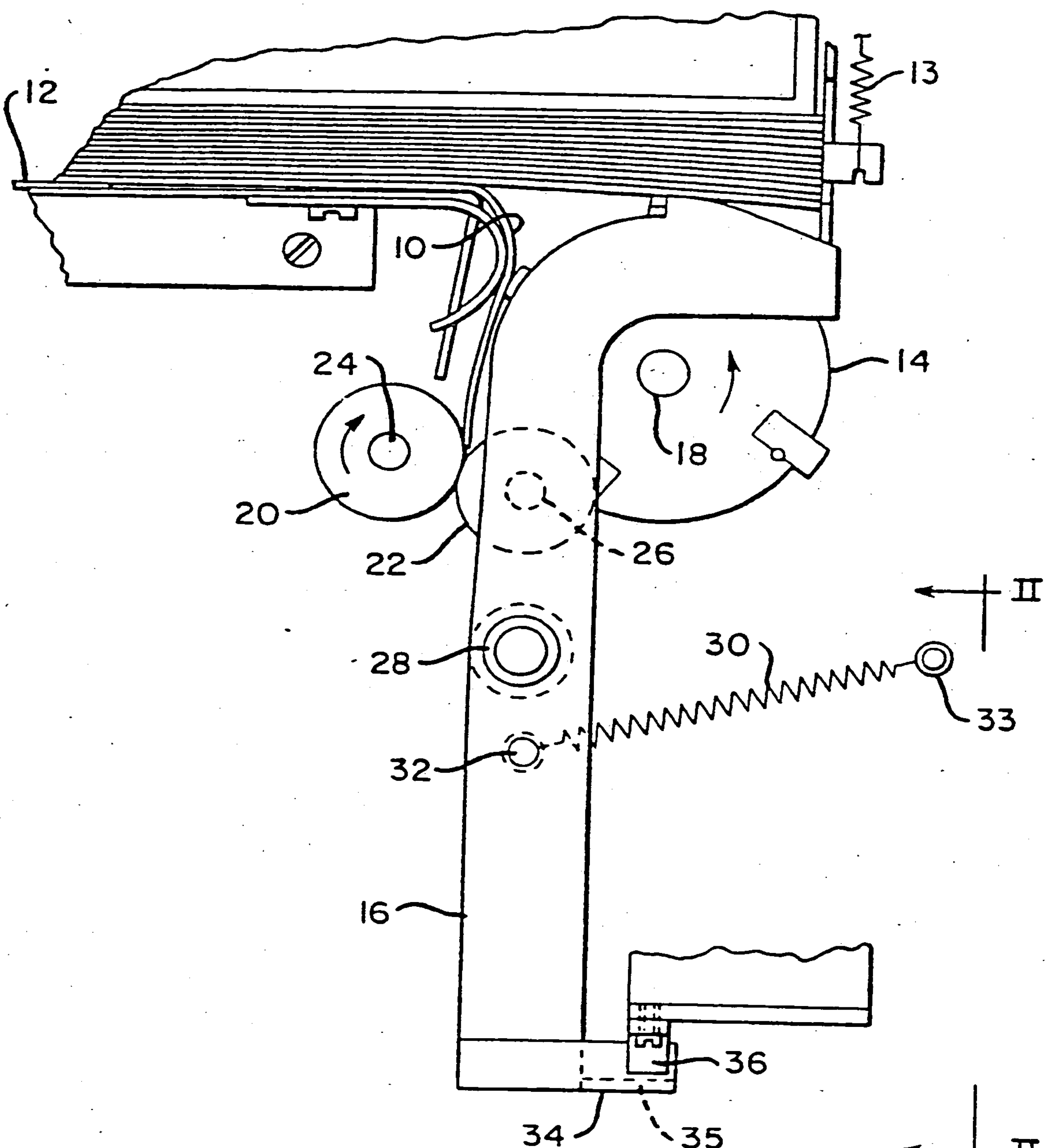
6. An apparatus according to claim 5, characterized in that the optical density of said control means (34) is graded linearly.

7. An apparatus according to claim 4, characterized in that said light source (46) is a photodiode, said light sensing means (40) is a phototransistor and said control means (34) is a strip of photographic film having a graded optical density.

8. An apparatus according to claim 1, characterized in that said circuit means (70, 92) is responsive to said output (45) from said detecting means (34, 36) for generating a plurality of signals (86, 104) indicative of certain conditions as the documents (10) pass through said gauging means (16, 20, 22).

9. An apparatus according to claim 8, characterized in that said circuit means (70, 92) generates a first signal (86) corresponding to a condition wherein multiple documents (10) simultaneously pass through said gauging means (16, 20, 22), and a second signal (106) corresponding to a condition wherein at least a single

FIG. 1



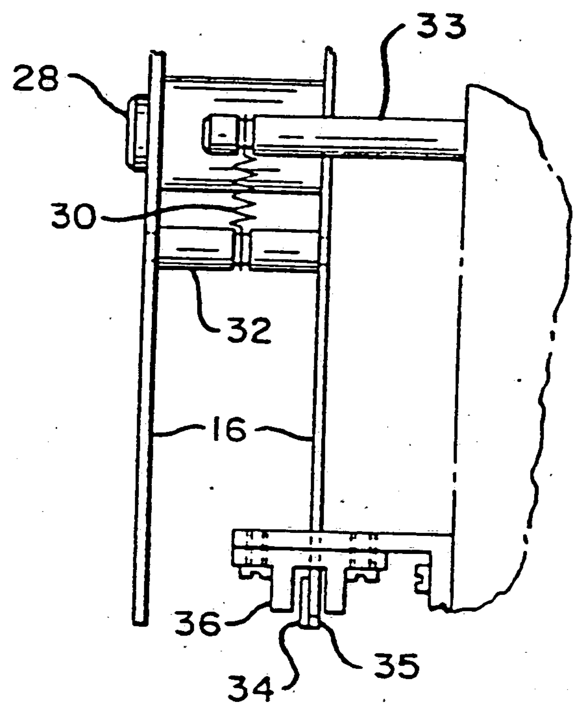


FIG. 2

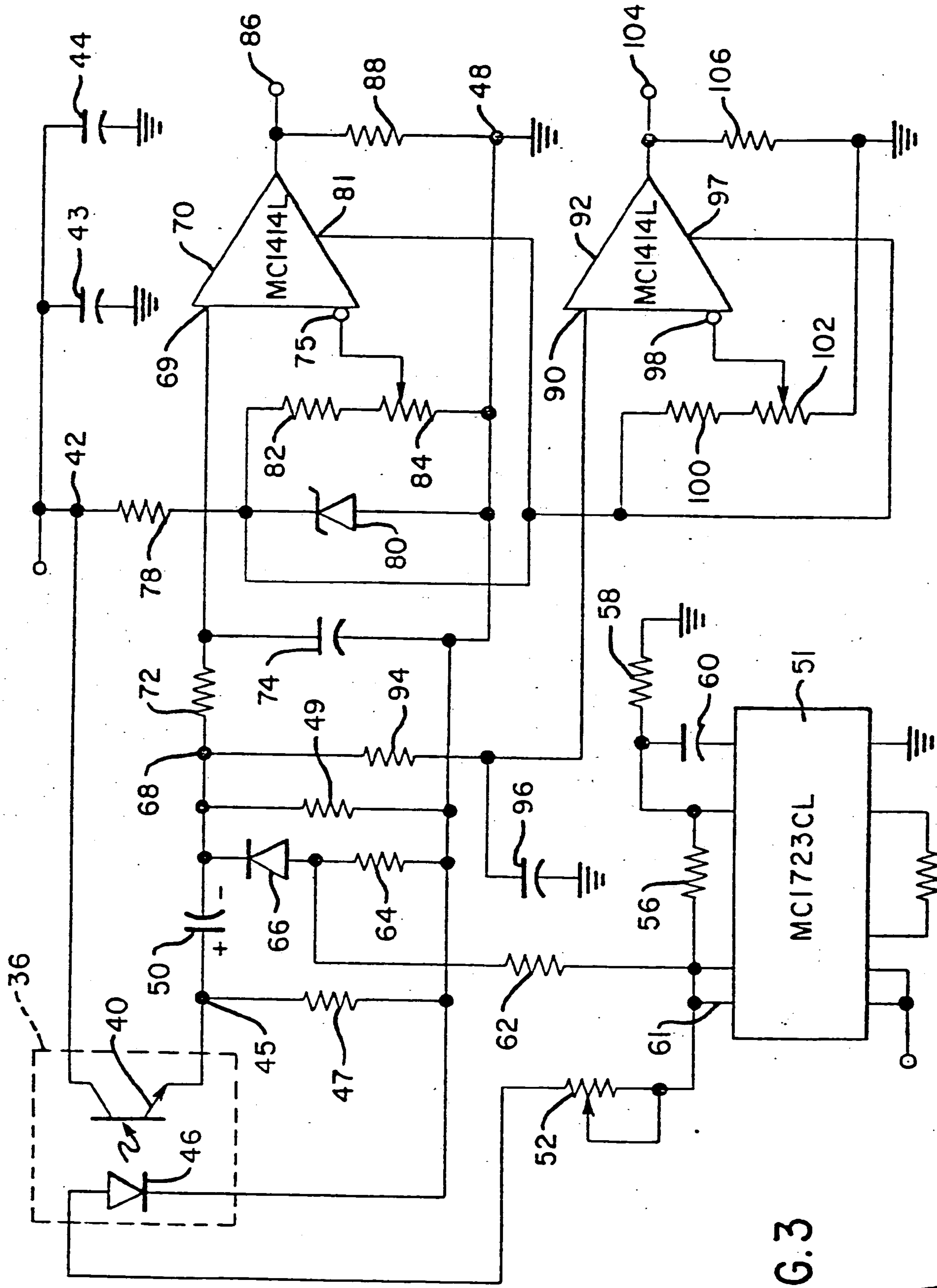
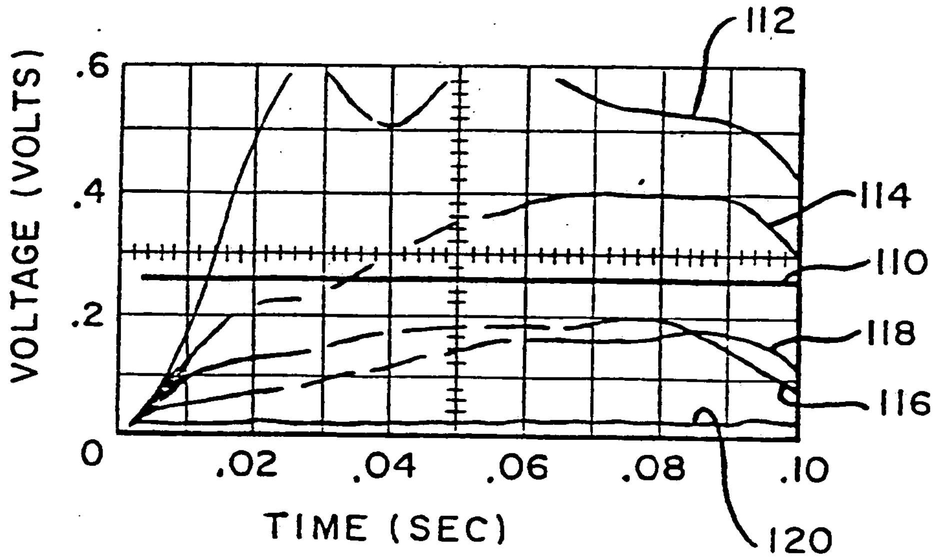


FIG.3

FIG. 6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114
110
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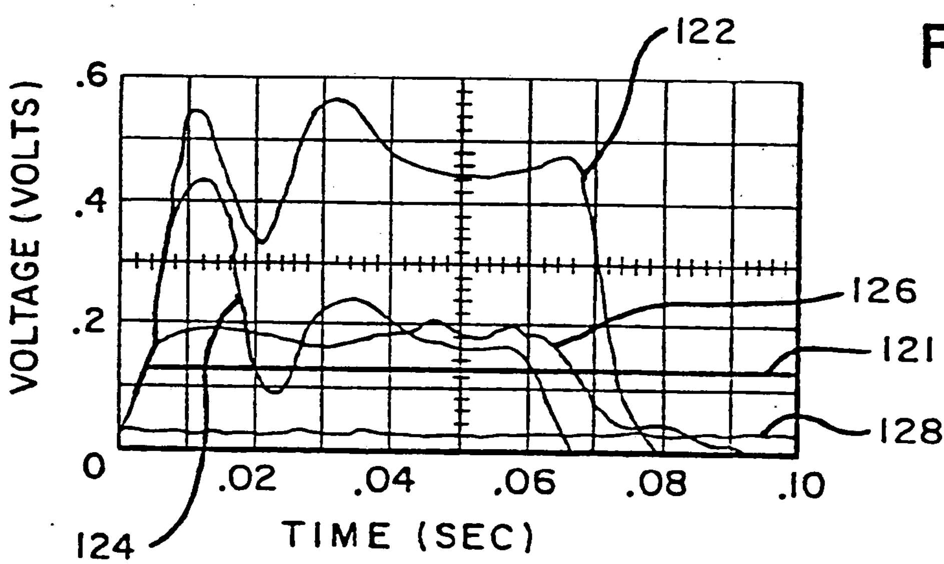
TIME (SEC)

FIG. 7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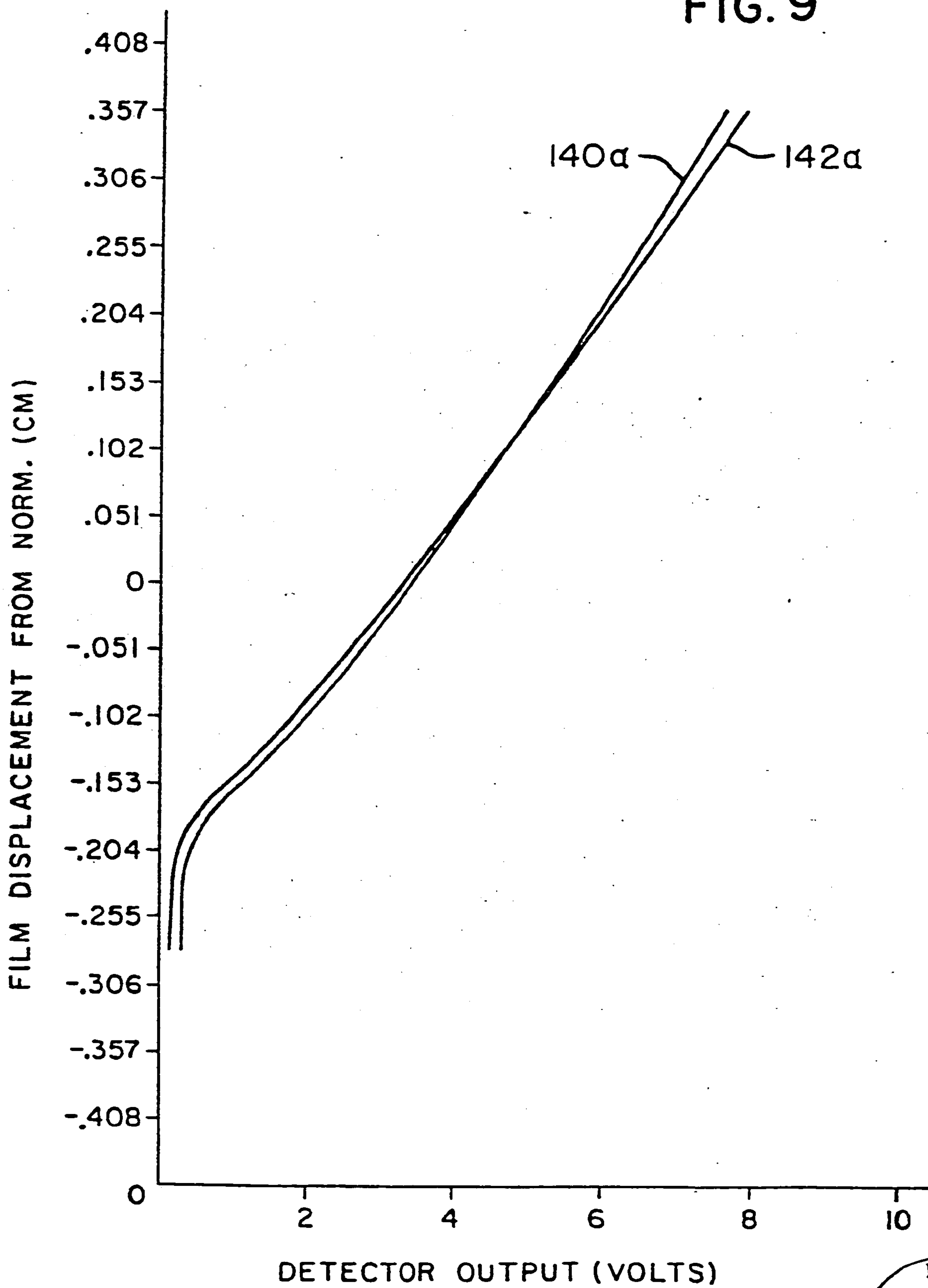
TIME (SEC)

FIG. 9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2
4
6
8
10
140a
142a
FILM DISPLACEMENT FROM NORM. (CM)
DETECTOR OUTPUT (VOLTS)